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(54) **Cylinder lock mechanisms**

(57) In a rotary disc cylinder lock, at least one tumbler 3 is selected during the course of assembly of the lock from a group of tumblers each having an equivalent geometrical relationship between its drive face 18 and its peripheral notch 12 but which differ in the profile of the key aperture adjacent to the drive face 29, 30 when assembled, if an implement 32 having a radial dimension greater than the maximum radial distance of the drive face 18 of such a tumbler from the axis of the lock is turned from the zero position within such a key aperture to align the peripheral notch 12 of the tumbler with the locking bar 8, it will therefore move through a different angle for different such tumblers in dependence upon the differences in said profiles. This serves to confuse an attempt to pick the lock by feeling the angle between the notch 12 and locking bar 8 with such an implement.

Fig.1

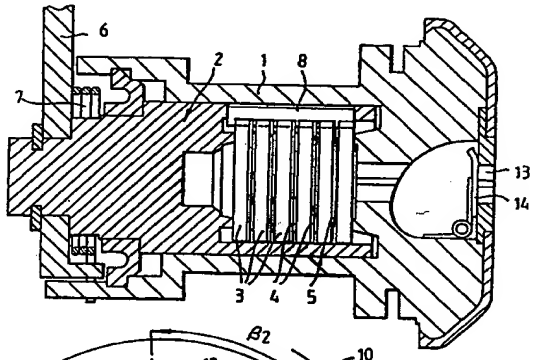


Fig.5

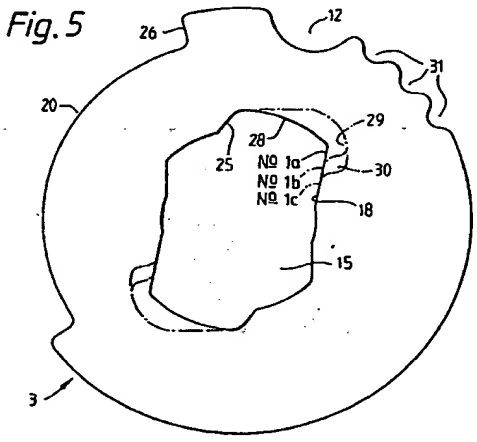
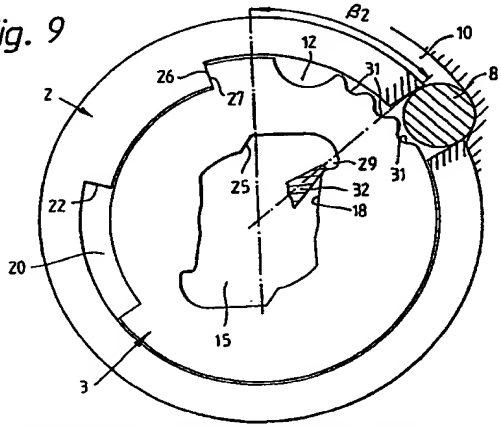


Fig. 9



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1

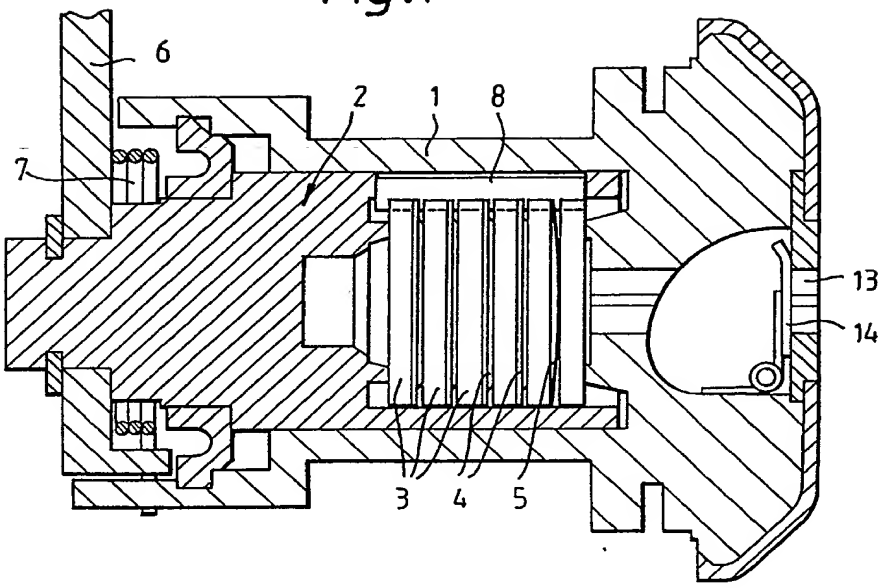


Fig.2

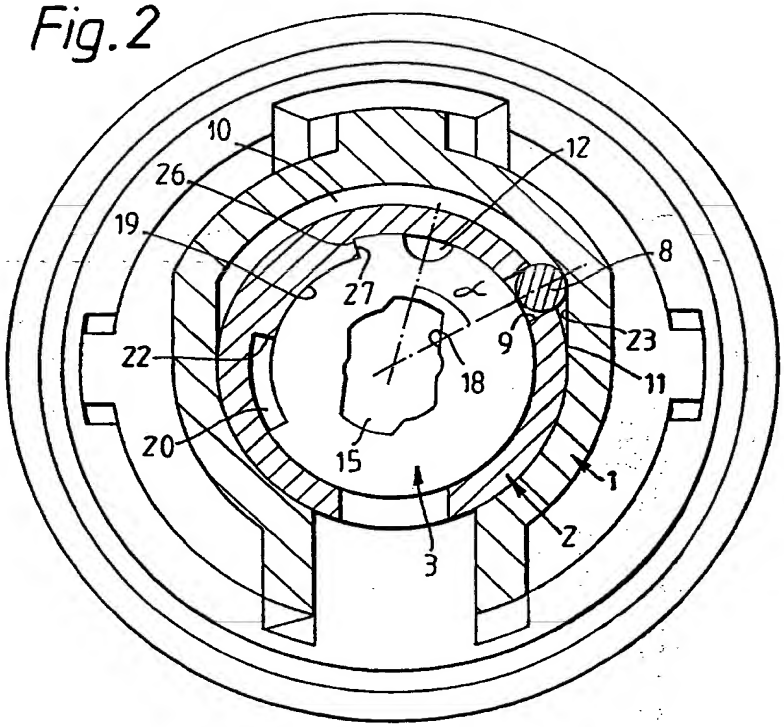


Fig.3

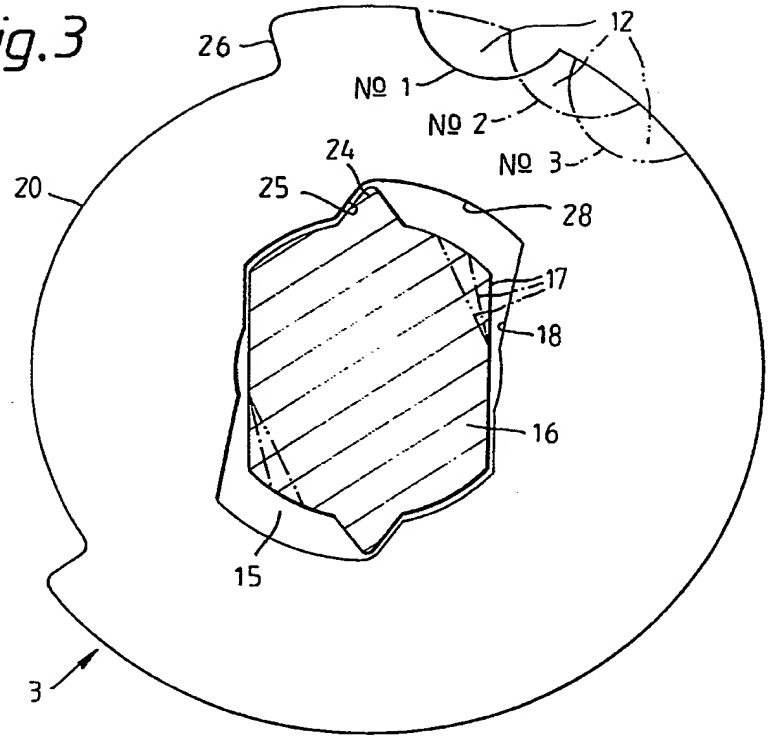


Fig.4

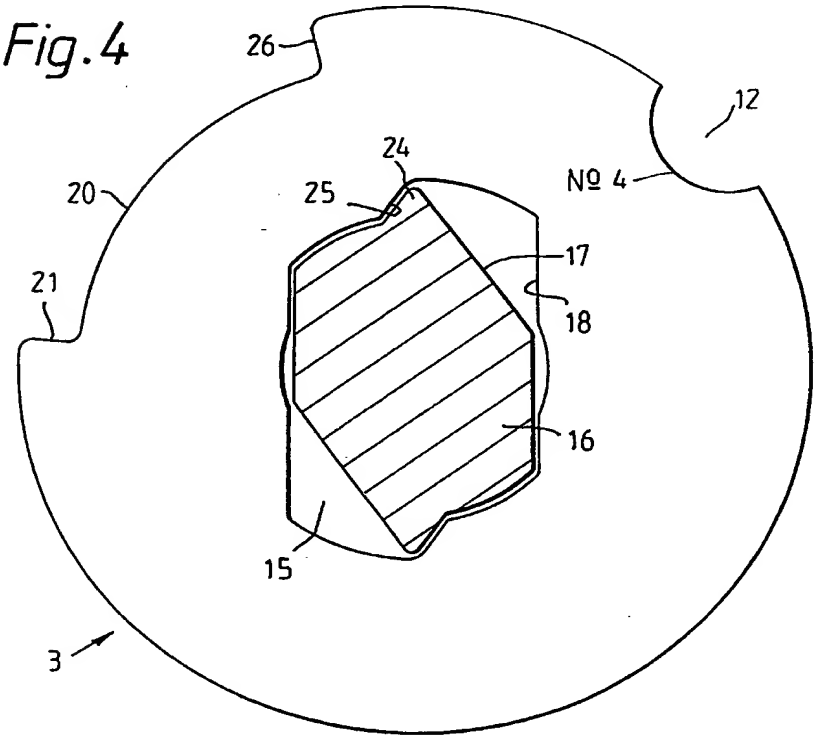


Fig. 5

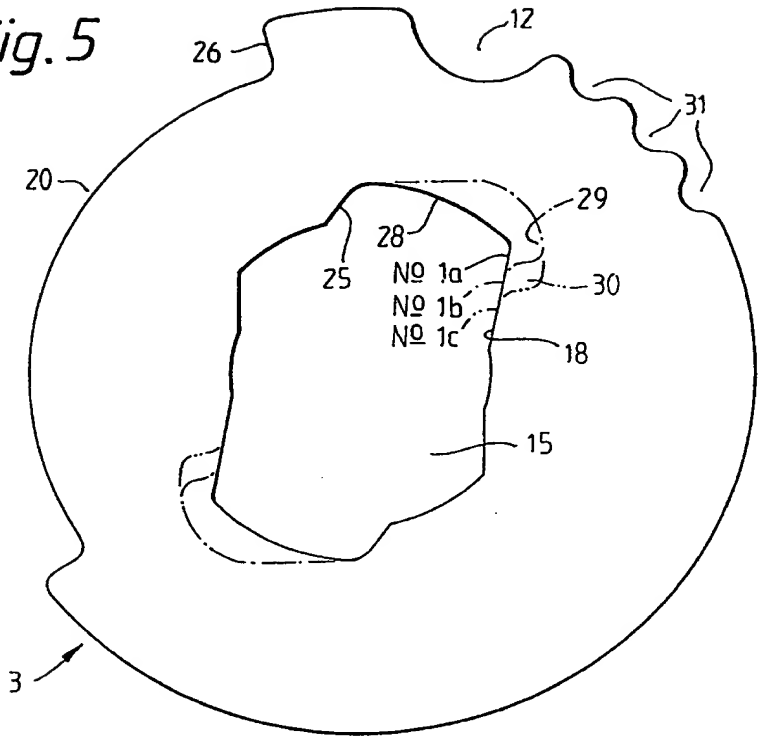

26
12
31
20
29
28
25
№ 1a
№ 1b
№ 1c
30
18
15
3

Fig. 6

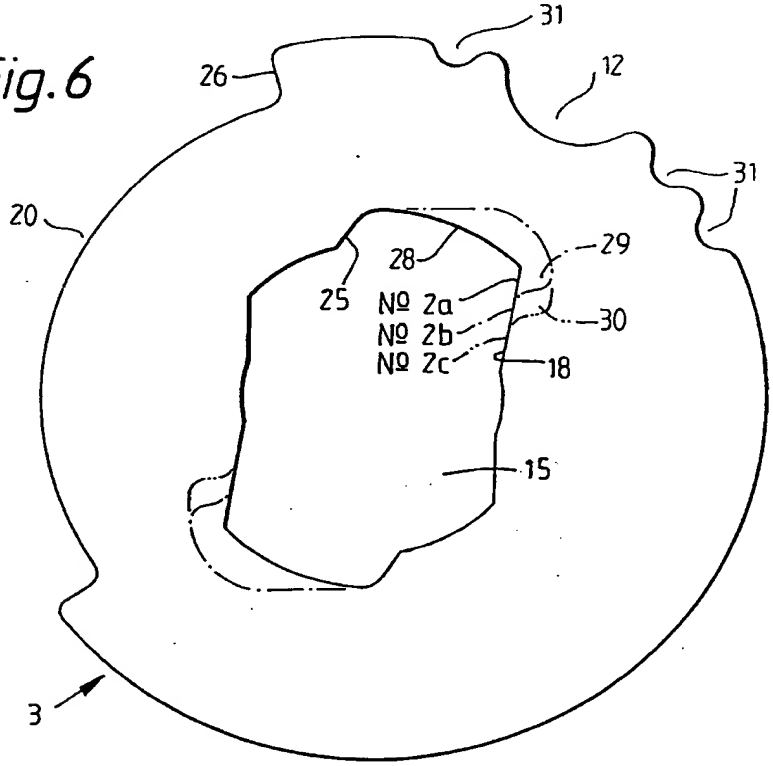

31
26
12
31
20
29
28
25
№ 2a
№ 2b
№ 2c
30
18
15
3

Fig.7

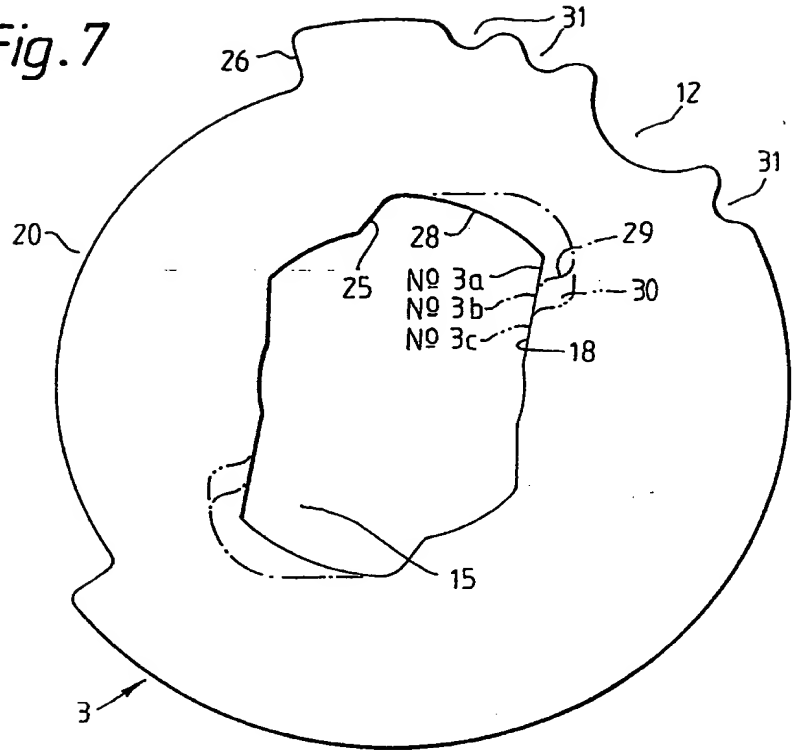
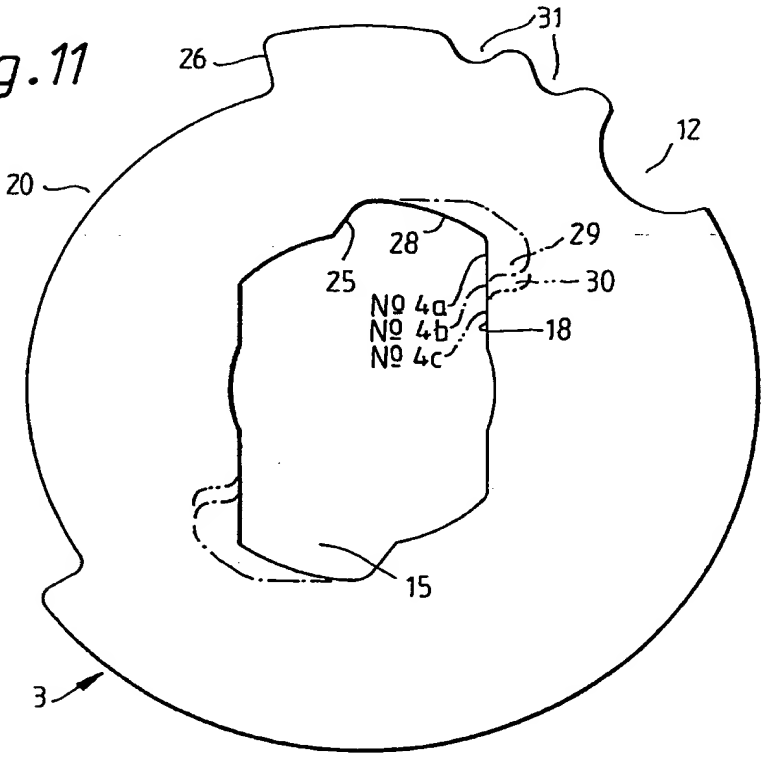

31
26
12
31
20
28
29
25
Nº 3a
Nº 3b
Nº 3c
30
18
15
3

Fig.11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28
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Nº 4a
Nº 4b
Nº 4c
30
18
15
3

Fig. 8

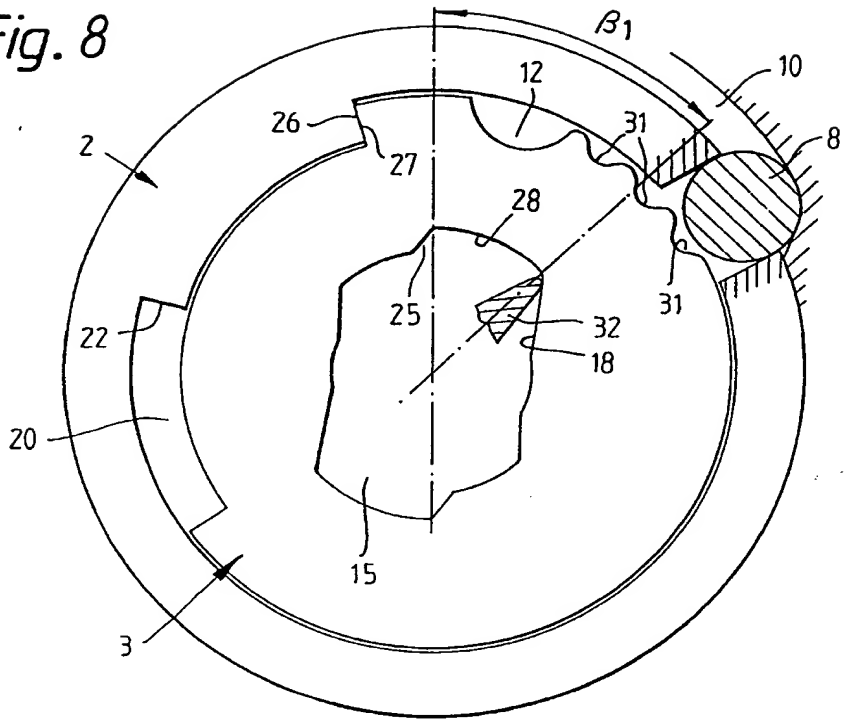
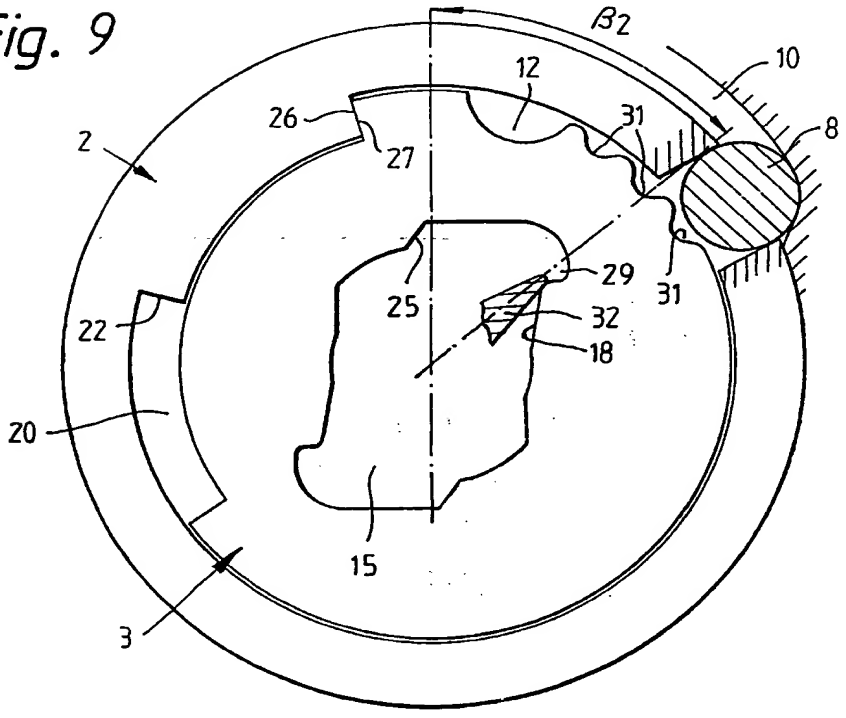

β1
10
12
26
31
8
2
27
28
25
31
32
22
18
20
15
3

Fig. 9


β2
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26
31
8
2
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29
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31
32
22
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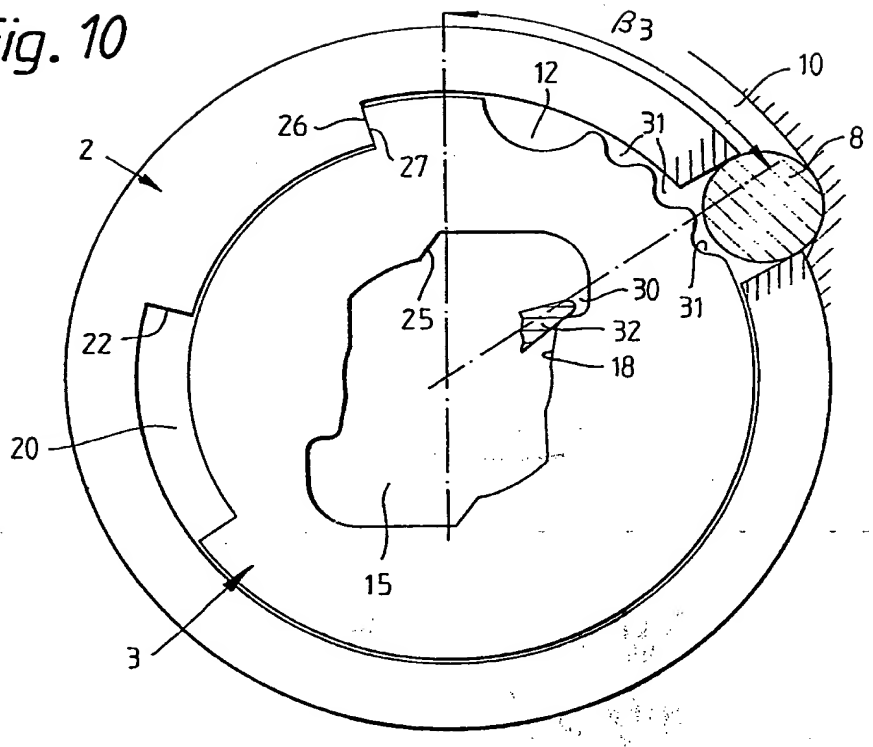
20
15
3

Fig. 10



Lock Mechanisms

The present invention relates to lock mechanisms and in particular to key-operated cylinder lock mechanisms of the kind employing rotary disc tumblers. Such mechanisms will hereinafter be referred to as "rotary disc cylinder locks" and some known examples of the same are disclosed in United Kingdom patent specifications or published patent applications nos. 1441026, 1482676, 1503586, 1543627, 1599137, 2021674, 2036851, 2038401, 2061368, 2161536, 2173852 and 2210660 and German patent application no. 3526173.

The basic mechanism of a rotary disc cylinder lock comprises a barrel which houses an axial series of rotary tumblers each having a peripheral notch located at a predetermined position and such that each tumbler can be turned by a correct key through a respective angle to align all the notches. The barrel is normally blocked against rotation relative to an outer housing by a peripheral locking bar held in a recess in the outer housing and extending across the shear line into the barrel. The locking bar is normally prevented from moving inwardly away from this position by resting on the peripheries of the tumblers. When the tumblers are turned to align all their notches with the locking bar, however, the locking bar can be received within the channel collectively formed by the tumbler notches and pass out of the housing recess to permit rotation of the barrel to an unlocking position.

The tumblers have central key apertures collectively defining a keyway and each tumbler is turned through the correct angle to receive the locking bar by means of a correctly angled cut on the key bit engaging part of the edge of the respective key aperture - which part we shall refer to as the "drive face". Upon return rotation of the key and barrel from the unlocking position the locking bar is returned to its barrel-blocking position in the recess of the outer housing and, as the key moves back to its insertion and withdrawal (or "zero") position, the tumblers are scattered to misalign their notches by the engagement of part of the key bit with another part of the edge of the respective key apertures. Movement of the locking bar into the aligned tumbler notches when the mechanism is unlocking is normally achieved by a camming action of the bar against an inclined face of the outer housing recess under torque applied to the barrel, and return movement of the bar into the housing recess when the barrel is returning to zero may be achieved e.g. by means of a spring or by a camming action of the tumbler notches against the bar - in which latter case the bar may be of cylindrical form, i.e. a roller.

Rotary disc cylinder locks are among the most secure of known cylinder lock types. Nevertheless, some theoretical methods of picking such locks have been suggested. These methods are not known to constitute a general threat because they require the use of special tools and very considerable expertise by the potential lock picker, and even then are time-consuming and uncertain. However, it is desirable to design a lock even against theoretical threats.

More particularly, it is postulated that an attempt might be made to gain information on the relative positions of the peripheral notches in the individual tumblers of such a lock by use of a probe which is inserted into the key

aperture and used to turn the tumblers one by one to feel for a change in frictional resistance which occurs when a notch encounters the locking bar. By thus determining the positions of all the tumbler notches by reading the angles through which the probe turns on each occasion a false key might be fashioned to open the lock; (note that the probe could not itself open the lock during the preceding operation because it must be turned back towards the zero position, thereby unsetting the tumbler which it has just felt, in order to be moved axially from one tumbler to the next). Such an attempt can be rendered more difficult by incorporating additional shallow notches in the peripheries of the tumblers - i.e. so-called false notches e.g. as shown at 30 in United Kingdom Patent Specification no. 2061368 - which confuse identification of the true notch positions. Nevertheless, given sufficient knowledge of all the possible forms of the tumblers in a particular type of lock an especially skilled person might be able to overcome the effects of false notching and accordingly it is an aim of the present invention to provide a rotary disc cylinder lock with even greater security against possible unauthorised manipulation.

In this respect it is postulated that for a picking probe to have sufficient sensitivity to successfully feel the minute changes in friction which could reveal the position of a tumbler notch it should have a radial dimension from the cylinder axis which is substantially the greatest that the key apertures in the tumblers will permit, and in particular is greater than the radial dimension of the correct key bit which is physically necessary to turn the tumblers by engagement of their drive faces.
Accordingly, in one aspect the present invention resides in a rotary disc cylinder lock of which at least one tumbler is selected during the course of assembly of the lock from a group of tumblers each having an equivalent

geometrical relationship between its drive face and its peripheral notch but which differ in the profile of the key aperture adjacent to the drive face whereby, in the assembled lock, if an element having a radial dimension greater than the maximum radial distance of the drive face of such a tumbler from the axis of the lock is turned from the zero position within such a key aperture to align the peripheral notch of the tumbler with the locking bar, it will move through a different angle for different such tumblers in dependence upon the differences in said profiles.

The effect of the invention is that if a picking attempt is made as postulated above then for each possible tumbler notch position there are a number of possible angles through which the probe will turn to "feel" that position, corresponding to the number of differs in key aperture profile in each group of otherwise equivalent tumblers. This will correspondingly complicate the task of identifying an individual tumbler notch position, and even more so if combined with the provision of false notches in the peripheries of the tumblers. More particularly, if it is arranged that notches at different positions on different tumblers in the lock become aligned with the locking bar by effectively the same probe movements by virtue of differing their key aperture profiles in accordance with the invention, then it will be practically impossible to distinguish between those tumblers by the method discussed.

The invention will now be more particularly described, by way of example, with reference to the accompanying drawings, in which:-

Figures 1 and 2 are respectively longitudinal and transverse cross-sectional views of a known kind of rotary disc cylinder lock to which the invention can be applied;

Figs 3 and 4 illustrate known kinds of rotary disc tumblers for incorporation in the lock of Figures 1 and 2;

Figures 5, 6, 7 and 11 illustrate modified forms of tumbler in accordance with the invention for incorporation in the lock of Figures 1 and 2; and

Figures 8, 9 and 10 illustrate in transverse cross-section the effect of the modified forms of tumbler in accordance with the invention on attempts to identify the tumbler notch positions by use of a picking probe.

Referring to Figures 1 and 2, these illustrate an example of a known kind of rotary disc cylinder lock to which the present invention can be applied, as is used e.g. for locking vehicle doors. It comprises an outer housing 1 within which a barrel 2 is borne, the latter housing an axial series of rotary tumblers 3, six in number in the illustrated example. Respective tumblers 3 are separated by spacers 4 keyed to the barrel, one of which is in the form of a dished spring washer 5 so as to maintain the tumbler pack under light endwise pressure. Carried at the tail end of the barrel 2 is an operating lever 6 which serves to lock or unlock the associated vehicle door mechanism in accordance with the direction of turning of the barrel in a respective sense from the illustrated central or zero position of the lock, and a double-acting return spring 7 serves to bias the barrel back to the zero position when turned in either sense away from that position.

In order to unlock the door mechanism the barrel 2 with its operating lever 6 must be turned relative to the housing 1 through an angle of approximately 45° from the zero position in the clockwise sense as viewed in Figure 2. This movement is normally blocked by a roller 8 held

partly in a radial slot 9 in the barrel and partly in a recess 10 of the housing 1, thus bridging the shear line 11 between the barrel and housing. The roller 8 is in this position blocked from moving inwardly away from the recess 10 by the peripheries of the various tumblers 3. Each such tumbler has a peripheral notch 12 at a predetermined position, however, so that when all of the tumblers are turned to align their respective notches to receive the roller 8 the latter can move radially inwards and the barrel can be turned. Alignment of the tumbler notches 12 to receive the roller 8 is achieved by a rotary movement of the respective tumblers relative to the barrel 2 by turning of a correct key inserted through the key-hole 13 at the front end of the housing 1, past a spring-loaded shutter 14 and into the keyway defined by central apertures 15 in the tumblers.

More particularly, in the specific example of lock illustrated herein the tumbler pack comprises a combination of four different patterns of tumbler each one of which must be turned through a different angle from the zero position in order to align its notch 12 with the roller 8. With a six tumbler lock, therefore, around 4,000 different combinations are possible. A first pattern of tumbler, which for convenience we shall refer to as a "No. 1" tumbler, is shown in Figure 2 and (in full line) in Figure 3. In the zero position the notch 12 of this tumbler is displaced from the roller 8 by the angle α (Fig 2) which is therefore the angle through which the tumbler must be turned in the barrel 2 by the proper key before it is in a position to receive the roller for unlocking. The cross-section of the proper key bit 16 for such a No. 1 tumbler is shown in full line in Figure 3 in the position of axial insertion into the tumbler aperture 15. Clockwise turning of the key through an initial angle of approximately 45° brings the face 17 of the key bit into contact with the drive face 18 of the

tumbler and thence turns the tumbler through the angle α. Two other tumbler patterns, which for convenience we shall refer to as "No. 2" and "No. 3" tumblers, are also indicated in Figure 3. The form of the central aperture 15 with drive face 18 is identical to that of a No. 1 tumbler, but the positions of the respective notches 12 around the peripheries of the tumblers are differed as indicated in broken line in Figure 3, thus being displaced from the roller 8 through different angles in the zero position. Figure 3 also indicates in broken line the different angles to which the face 17 of the key bit is cut for registration with these tumblers so that they are all turned to align their respective notches 12 with the roller 8 when the key is given its initial 45° turn. The remaining pattern of tumbler, which for convenience we shall refer to as a "No. 4" tumbler is shown in Figure 4, together with the cross-section of the proper key bit 16 cut at 17 to align the respective notch 12 with the roller 8 by contact with the drive face 18 of the tumbler aperture 15 during the same initial 45° turn of the key.

The limits of permissible turning of the tumblers 3 in the barrel 2 are set by an axial rib 19 of the latter extending into peripheral recesses 20 in the tumblers. Comparison of Figures 3 and 4 shows that the circumferential extent of the recess 20 in a No. 4 tumbler is less than that for the other patterns. Consequently, when the tumblers have all been turned to align their notches 12 with the roller 8 the edge 21 of a No. 4 tumbler recess comes into contact with the edge 22 of the barrel rib, so that further clockwise turning of the key applies torque to the barrel 1 through the No. 4 tumblers(s) in the pack. Clockwise torque upon the barrel presses the roller 8 against the inclined face 23 (Fig. 2) of the housing recess 10 and therefore cams the roller inwardly into the aligned tumbler notches 12, thereby allowing the roller, barrel and tumblers to turn

together with the key through the angle required to unlock the associated door mechanism; the total turning angle of the key in this direction is therefore approximately 90°.

Having unlocked the door, the key is turned back towards the zero position, which allows the barrel 2 likewise to return under the action of the spring 7. The barrel centralises with the roller 8 aligned with the clockwise (as viewed) end of the housing recess 10, whereupon continued movement of the key back to the zero position engages its radial rib 24 (Figs 3 and 4) in turn with the edges 25 of the respective tumbler apertures, to return the tumblers to their own initial positions with their notches 12 misaligned with the roller 8. In so doing the roller 8 is cammed out of the tumbler notches 12 and returned to its blocking position of Figure 2.

It will be observed that the form of each tumbler aperture 15 and of the corresponding section of the key bit 16 is symmetrical about a median plane, so that the proper key will operate the tumblers to unlock in the same fashion when inserted either way up. This can in fact be achieved by forming only the apertures 15 or the bit 16 symmetrically but for convenience both are so formed.

In order to lock the door mechanism the barrel 2 with its operating lever 6 must be turned relative to the housing 1 through an angle of approximately 45° from the zero position in the opposite sense to unlocking, i.e. counter-clockwise as viewed in Figure 2. Turning of the barrel in this sense is unrestricted by the roller 8 as the housing recess 10 extends around the barrel 2 through a sufficient angle to accommodate the roller throughout this movement. All that is required to lock, therefore, is to insert the key and turn it counter-clockwise through the appropriate angle. Torque is applied to the barrel in this sense from the key rib 24 contacting the edges 25 of

the tumbler apertures and the edges 26 of the tumbler recesses contacting the edge 27 of the barrel rib 19. Having locked the door, the key is turned back to the zero position, which allows the barrel and tumblers to return with it under the action of the spring 7. No relative movement between the tumblers and barrel therefore need take place in this operation.

As thus far described, the illustrated lock is of a known kind which has been successfully implemented for vehicle locking over a considerable period and is generally recognised to provide a level of security superior to most other conventional cylinder lock types. As previously indicated, however, theoretical picking methods have been postulated and there will now be described a modification to the tumblers in accordance with the invention which aims to enhance even further the security of this kind of lock.

In accordance with the invention, each No. 1, No. 2 and No. 3 tumbler employed in the pack is selected during the course of assembly from a respective group of, say, three such patterns which differ in the profile of their key apertures 15 so as to be indistinguishable in terms of their operation by the correct key but so as to respond differently to a picking attempt as postulated in the introductory part of this specification. These differs are illustrated in Figures 5, 6 and 7 for the No. 1, No. 2 and No. 3 tumblers respectively.

Referring to Figure 5, this shows in full line the profile of the aperture 15 of a first pattern of No. 1 tumbler, which for convenience ws shall refer to as a "No. 1a" tumbler. It is in fact the same as the No. 1 tumbler pattern previously illustrated, with the edge which comprises the drive face 18 extending from close to the median plane of the tumbler to an edge 28 of the aperture

which has a radius to accommodate the rib 24 of the key bit. A first variation from this is indicated in broken line in Figure 5, where the length of the edge which comprises the drive face 18 is truncated and the aperture is opened out to form a lobe 29 at the upper end of that edge. For convenience we shall refer to this pattern as a "No. 1b" tumbler. A second variation is indicated in chain line in Figure 5, where the length of the edge which comprises the drive face 18 is truncated further and the aperture is opened out to form a more extensive lobe 30 at the upper end of that edge, for convenience this pattern being referred to as a "No. 1c" tumbler. In addition, a series of serrations 31 to form false notches is provided in each of these tumblers adjacent to the true notch 12 along that part of the periphery which can come into contact with the roller 8. Referring to Figures 6 and 7, these indicate the same three alternative key aperture profiles for No. 2 and No. 3 tumblers as are indicated for No. 1 tumblers in Figure 5, together with respective series of false notches 31 adjacent to the true notches 12.

As previously indicated, each of the three variants of a respective tumbler pattern will function in the same way for unlocking with the correct key and are thus interchangeable in this respect. That is to say, comparison of Figures 5-7 with Figure 3 will show that the cut face 17 of the respective key bit section will contact the drive face 18 of each variant of the respective corresponding tumbler pattern at the same angle and over the same effective length. In this respect it is observed that the actual length of the drive face contacted by the key in each variant corresponds only to the length of the face in a "c" variant - i.e. the provision of lobes 29 and 30 does not reduce or otherwise affect the contact with the key as compared with the unmodified or "a" aperture profile. Postulating,

however, that if a picking probe is to be used in an attempt to "feel" the positions of the notches 12 then it will be of the maximum radius which can be accommodated by the tumblers (i.e. equivalent to the radius of the key rib 24), then the presence of the lobes 29,30 in different tumblers having the same notch positions will serve to confuse the attempt as explained below with reference to Figures 8-10.

Figure 8 is an impression of the use of a probe 32 in the course of turning from the zero position to contact a No. 1a tumbler and then turn that tumbler until it is felt that its notch 12 has aligned with the roller 8, thereby to identify that tumbler as a No. 1 tumbler by observation of the angle through which the probe has turned from the zero position to reach the aligned position. It is shown at the point of contact with the edge of the tumbler aperture 15, which occurs at the upper end of the edge which comprises drive face 18, close to the junction with edge 28. At this point the probe has been turned through an angle β_1 of approximately 45° from the zero position, and must be turned through the further angle which is required to align the notch 12 with the roller 8. In Figure 9 there is shown the same operation but where the tumbler is instead of No. 1b' pattern. In this case the probe will contact the edge of the tumbler aperture at the junction of the lobe 29 with the edge which comprises drive face 18 and therefore turns further before contacting the tumbler than in the case of the 1a pattern. The angle β_2 is in this case approximately 50° and the probe must then turn the tumbler through the same angle to align its notch 12 with the roller 8 as in the case of the 1a pattern. Figure 10 again shows the same operation but in this case where the tumbler is of No. 1c pattern. The probe now turns even further before contacting the tumbler, which occurs at the junction of the lobe 30 with the drive face 18, the angle β_3 in this case being

approximately 55°. Again the probe must then turn the tumbler through the same angle to align its notch 12 with the roller 8 as in the case of the other No. 1 patterns.

It follows that the total angle through which the probe 32 will turn from the zero position to align the notch 12 of a No. 1 tumbler with the roller 8 will vary in accordance with whether the tumbler is of "a", "b" or "c" pattern. This will serve to confuse the identification of the tumbler as being a No. 1 tumbler even if it is possible to distinguish when the notch 12 has been aligned with the roller 8, which will in itself be confused by the presence of the serrations 31. Similar effects will apply to the use of the probe to "feel" the notch positions of No. 2 and No. 3 tumblers, due to the similar variations of key aperture profile as between the "a", "b" and "c" patterns illustrated in Figures 6 and 7. Indeed the combined effect of the variations in key aperture profile and the provision of the serrations 31 may make it quite impractical to distinguish examples of Nos. 1, 2 and 3 tumblers from each other by operation of a probe in the manner contemplated.

In a modification of the lock described above each No. 4 tumbler is also open to variation as to the profile of its key aperture in a manner equivalent to that described for the Nos. 1-3 tumblers, thereby increasing still further the complexity of any picking attempt. The differs for a No. 4 tumbler are illustrated in Figure 11, where three alternative key aperture profiles are indicated respectively in full, broken and chain lines, the latter two variations comprising lobes 29 and 30 respectively. False notches are also indicated at 31. In this modification also, the No. 4 tumbler is no longer employed for transferring torque from the key to the barrel, and its recess 20 is extended to the same extent as the Nos. 1-3 tumblers. In this case drive is transferred to the

barrel directly by a formation at the end of the key bit, lost motion being provided as necessary in the unlocking direction for the initial 45° turn of the key to align the tumbler notches 12 with the roller 8.

CLAIMS

1. A rotary disc cylinder lock, at least one tumbler of which is selected during the course of assembly of the lock from a group of tumblers each having an equivalent geometrical relationship between its drive face and its peripheral notch but which differ in the profile of the key aperture adjacent to the drive face whereby, in the assembled lock, if an implement having a radial dimension greater than the maximum radial distance of the drive face of such a tumbler from the axis of the lock is turned from the zero position within such a key aperture to align the peripheral notch of the tumbler with the locking bar, it will move through a different angle for different such tumblers in dependence upon the differences in said profiles.

2. A lock according to claim 1 wherein tumblers in said group differ by the provision of lobes of different dimensions in the key aperture adjacent to the drive face.

3. A lock according to claim 1 or claim 2 wherein a plurality of tumblers are selected during the course of assembly of the lock from respective groups of tumblers, each member of a respective group having an equivalent geometrical relationship between its drive face and its peripheral notch but differing in the profile of the key aperture as aforesaid, wherein it is arranged that for at least some selections of tumblers from said respective groups the peripheral notches at different positions on different tumblers in the assembled lock will become aligned with the locking bar by turning an implement as aforesaid through substantially the same angle.

4. A lock according to any preceding claim wherein at least some tumblers are provided with further peripheral notches adjacent to the respective first-mentioned

peripheral notch, the further peripheral notches being dimensioned not to receive the locking bar to a sufficient depth to pass out of the housing recess.

5. A rotary disc cylinder lock substantially as hereinbefore described with reference to the accompanying drawings.

16

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
GB 9306513.4

Relevant Technical fields

(i) UK Cl (Edition L) E2A (ALT, ALQ)

(ii) Int Cl (Edition 5) E05B 29/00

Search Examiner
P A MAKIN

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search
29 JUNE 1993

Documents considered relevant following a search in respect of claims 1-5

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	GB 2210660 (WILLENHALL) whole document	1
A	GB 1577246 (MILLER) whole document	1

SF2(p)

jf - doc99\fil000548

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

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